Measurement and Analysis

... at the atomic level

Advances in science are tied to the availability of state-of-the-art instrumentation and techniques for measurement and analysis. Inevitably this means that developing new measuring tools goes hand in hand with progress in the laboratory

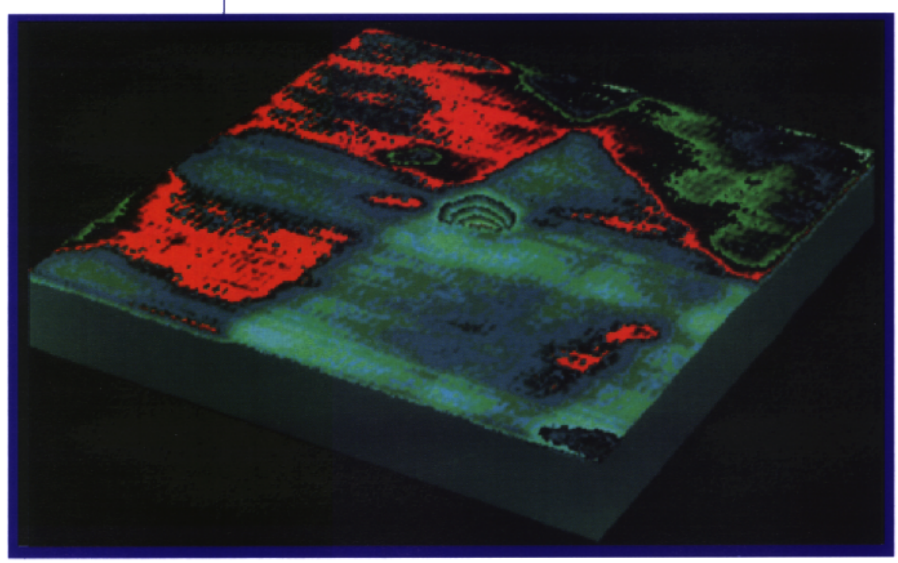
BES researchers are at the forefront when it comes to developing new instruments and techniques to identify and quantify atoms. This remains a key capability in an age when the purity and composition of materials are crucial to the success of manufacturing processes, from ultraminiaturized microelectronic chips to high-strength alloys. Equally critical is the ability to quantitatively identify chemical compounds.

Microscopes based on electrons or X-rays are part of the vanguard of analytical instrumentation, and BES and industry are working together to make full use of these vital capabilities. Some microscopes have such high magnification that researchers can see individual atoms, while others combine imaging with elemental and chemical analysis. Still others provide three-dimensional views of the interiors of otherwise opaque samples.

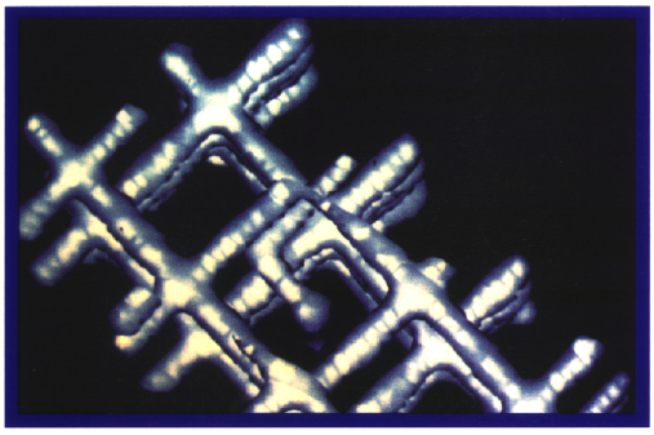
BES researchers are working closely with their counterparts in the private sector to expand the arsenal of tools available for measuring the physical, chemical, and biological attributes of matter. Whether semiconductor, superconductor, permanent magnet, laser, metal alloy, ceramic, polymer, or disease-fighting pharmaceutical, the fitness of the material for its intended purpose is determined through its properties.

In addition, the discovery of new materials is often made possible by correlating material properties with material functions. Combining materials theory with experiments helps researchers understand the material and develop the ability to predict its performance, and ultimately, it is hoped, to customize new materials with desired properties.

Instruments that can glimpse the intimate details of processes in real time (as they are happening) provide an essential tool for an enormous variety of needs, ranging from monitoring the quality of parts in a production line to investigating the progress of deterioration due to corrosion or other forms of degradation.



The inter-facial force microscope allows researchers to create three-dimensional topographic images of surfaces without causing damage. This image, from an instrument developed under a cooperative research and development agreement among Sandia National Laboratories, Digital Instruments, Lucent Technologies, and the University of New Mexico, shows an indentation about 75 nanometers in diameter positioned near atomic crystal terrace steps on a gold surface.

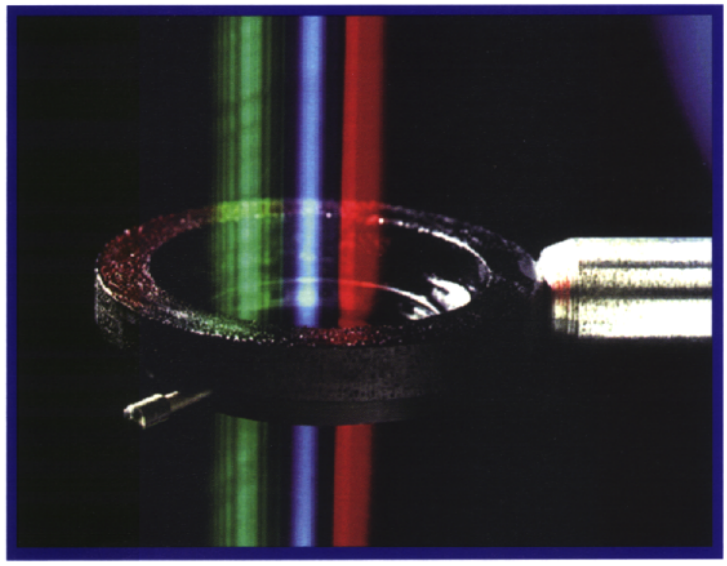


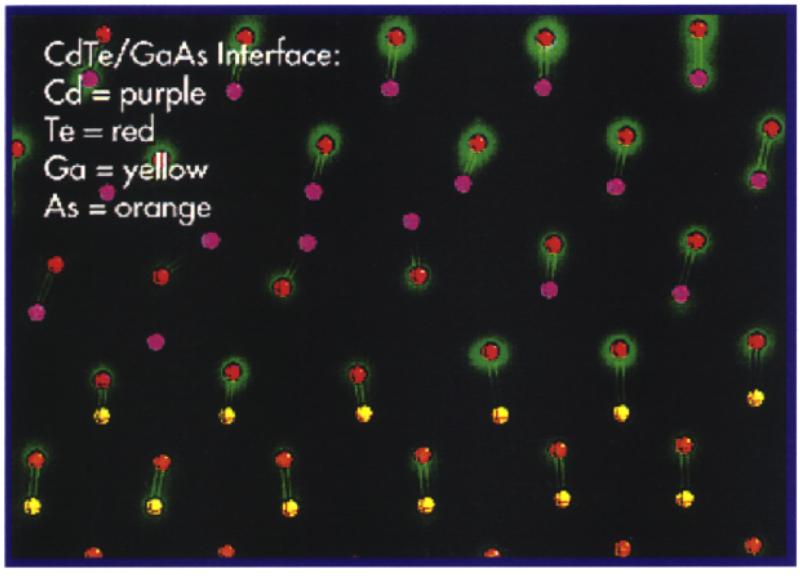
Three-Dimensional Imaging

Scientists from IBM Research and Exxon Research and Engineering Co. are using X-rays from the National Synchrotron Light Source at Brookhaven National Laboratory to make three-dimensional images of the interior of complex electronic components (such as the internal wiring of the package on which computer chips are mounted shown here) and thereby test the effectiveness of manufacturing methods.

Laser-Based Analysis

Scientists at Argonne National Laboratory have developed a sophisticated laser method, "Surface Analysis by Resonant Ionization of Sputtered Atoms" — SARISA, for short-to uniquely identify and accurately measure trace impurities in solid materials. SARISA uses up to three beams of different wavelengths (colors) to characterize the impurities. Together with scientists at SEMATECH, BES researchers demonstrated the effectiveness of this method for analyzing silicon wafers used in manufacturing computer chips





Electron Microscopy

Z-contrast electron microscopy, a technique that uses new instrumentation developed jointly by VG Microscopes and the Oak Ridge National Laboratory, combines atomic resolution with elemental identification, as illustrated in this computer-enhanced image of the interface between two semiconductors, cadmium telluride and gallium arsenide. Winner of an R&D 100 award, this technique is now in use at several major laboratories.